# PATENT SPECIFICATION (11) 1 474 394

1 474 394

(21) Application No. 27539/74 (22) Filed 21 June 1974
(31) Convention Application No. 7322755 (32) Filed 21 June 1973 in
(33) France (FR)
(44) Complete Specification published 25 May 1977
(51) INT CL² A23P 1/00 A23L 1/00//1/195
(52) Index at acceptance
A2B 1B 1C 1D 1E 1F 1G 1H 1JY 1L 1X


(19)


## (54) IMPROVEMENTS RELATING TO PROCESSES FOR COOKING, EXTRUDING AND EXPANDING FOOD MIXTURES

(71) We, ISOCHEM S.A., a French Société Anonyme, of 10, rue Clément Marot, 75008 Paris, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

The present invention is concerned with a new process of cooking, extruding and expanding a food mixture, containing starch, possibly associated with protein. It also relates to the application of the said process for preparing in particular dietetic cooked products with fine and regular honeycomb or cellular structure of low density, in particular "instant" semolina and flour.

It is known that extrusion cooking, which consists first of all of cooking in the mass a food mixture containing starch, and then shaping the cooked mixture by extruding through a draw-plate leads, after cutting up to the required dimensions, to an expanded product which is known by the generic term of "snack". It is also known that by crushing snacks prepared from food mixtures containing starch and proteins, it has been possible to obtain dietetic flours and semolinas that can be used in particular for making instant stews and gruels and beverages.

The technique of extrusion cooking of the prior art for making dietetic snacks, in particular those described by H. J. H. de Muelenaere et al, Food Technology (1969) 23, 71—77, G. C. Mustakas et al, Food Technology (1970) 24, 102—108 and M. André, Industrie Alimentaire Agricole (1970) pages 1131—1140, imply primarily cooking in the presence of considerable humidity (25 to 30% by weight, including the water of constitution), the contribution of water being essential to obtain expansive extrusion by means of a draw-plate. To lessen the water content from 1 to 3% it is known that the incorporation of an emulsifier in the food mixture has been envisaged.

A comparison of the extrusion cooking devices made by the authors mentioned above, in particular by H. J. H. de Muelenaere et al and Mustakas et al, has shown that the extruder cooker of the most efficient type was a device provided with an extrusion worm, for preference with double thread, and advantageously heated with steam, which device is possibly provided with a pre-cooking worm which is arranged below the charging store.

Generally speaking, extruder cookers of this type, of the "single worm" type, so-called owing to the presence of only one extrusion worm, operate at a temperature from 120° to 140°C (inner temperature, i.e. that of the mix being treated). This type of extruder cooker includes the device that is described in British Patent No. 1,174,906.

It has been found with some surprise that it is possible to prepare sterile snacks from a macrobiological point of view, and useful in dietectics and/or for therapy, with substantial saving in the cost of power, by limiting as far as possible the quantity of water to be added to the raw food mixture before being treated.

It has been possible to put the invention into effect by determining three critical factors: —

The total water content of the mixture being treated;

The absence or low content of fats in the said mixture; and

The material needed for carrying out the process for cooking, extrusion, expansion.

The total water content will be from 14 to 16% by weight in relation to the weight of the mixture of raw food. This total water content corresponds practically to the content of water of constitution, also termed "residual humidity" of flours and semolinas of raw cereals. In this case, the continuous treatment is carried out without the contribution of water, the continuous cooking of the starch being carried out solely in the presence of the actual humidity of the starch.

On the other hand, if the continuous cooking is performed of a pretreated starch, i.e. having low residual humidity, water is added to the mixture to obtain a total water content of 14 to 16% by weight.

It has moreover been possible to observe

that the technique of extrusion cooking with a total water content of 14 to 16% made possible shorter lengths of treatment than those of prior art, and avoided the consumption of energy for drying the snacks after extrusion. According to the processes of prior art, a snack is extruded which has at least a water content of 20 to 25%, while according to the proposed process a snack is obtained having a maximum of 6 to 8% residual water, and this water content must afterwards be lowered to 4% to produce instant flour and semolina. This difference in the water content of the products that have just been extruded leads to savings of energy and equipment for drying. Experience shows that an extruded and finely honeycombed product obtained according to the process to be described below and containing 7% humidity is rigid, dries very rapidly by warm air ventilation, the crushing of the extrudate and its transformation into semolina making it possible to obtain direct a granulated product containing 4 to 5% water. Thus the process of the invention leads to the obtaining of a finished product without it being necessary to make provision for the troublesome use of the complicated drying devices of prior art, to obtain a humidity content of 4 to 5% by weight.

One of the aims of the invention is to preserve without deterioration the essential amino acids, and without great change the vitamins of the B group that are contained in the raw food. This is advantageously obtained by the fact that no water is added during the continuous cooking process, or else only a very small quantity of water is added and heating is performed for very short periods at a high temperature. This constitutes a considerable advantage in relation to the extrusion cooking techniques of prior art.

Another aim of the invention is to prepare dietetic products from raw starch and soya, while destroying the micro-organisms contained in the soya, the trypsic inhibitors and the odour of the soya. These perfectly balanced dietetic products may contain up to 25% by weight of proteins or more, which it was difficult to carry out and to conceive of by extrusion cooking in a single operation hitherto without continuous humidification.

The process of cooking, extrusion and expansion, according to the invention, of the food mixture containing starch, possibly associated with protein substances and vitamins, is such that the food mixture which contains the crude starch, a quantity of fatty materials from 0 to 2% by weight in relation to the weight of the said food mixture and a total quantity of water from 14 to 16% by weight in relation to the weight of the said food mixture, is cooked, extruded and expanded by means of an extrusion press having (a) two co-penetrating worms and a draw-plate preventing the stagnation of the material and (b) at least one heating device.

According to a preferred embodiment, the food mixture is subjected to heat treatment at a pressure equal to or greater than 200 kg/cm$^2$ for 20 to 150 seconds.

For preference, the heat treatment comprises at least two stages: preheating to 40°C and heating to a temperature between about 120° and 180°C. Between preheating at 40°C and heating at 120°—180°C, as well as during the said heating to 120°—180°C, it is possible to envisage several stages of increasing temperature.

It is essential that the original food mixture should contain little or no fats; the maximum content of fats that is tolerated is 2% by weight in relation to the weight of the said mixture. Indeed, if the fat content is higher, extrusion is still performed, but its expansion is much reduced.

Not all the extrusion cooking devices are suitable for effecting expansion according to the process of the invention. Indeed, expansion is impossible with the extrusion devices of the single screw type of the prior art, which were specially designed for the food industry. It has been possible to carry out the present process thanks to a device with two co-penetrating extrusion worms, initially intended for the extrusion of plastics as described in French Patents No. 1,320,462, 1,323,575 and 1,337,310.

In the course of carrying out the process of the invention good results were obtained in particular with two extruders for plastics materials made by Messrs. Creusot-Loire (types BC 45 and BC 72).

The extruder BC 45 comprises a compression tube of 60 cm inside which the two co-penetrating worms, rotating in the same direction, have a speed of rotation of 28 to 30 r.p.m. (the "single worm" devices operate at over 300 r.p.m.). Heating is by induction with at least two heating rings, the former for preheating to 40°C, and the latter for obtaining cooking between 120° and 180°C. By way of example with three heating rings, the heat treatment comprises in particular preheating at 40°C for 40 seconds, heating at 120°C for 40 seconds and then a final heating at 160°C for 40 seconds, or possibly a preheating at 40°C for 50 seconds, heating at 70°C for 40 seconds and then heating at 170°—180°C for 30 seconds. The delivery of finished products (snacks) is 30 to 40 kg/h with this type of extruder.

Generally speaking, the heat treatment is performed for 20 to 150 seconds according to the speed of rotation and the models of the double worm press.

With the devices described above, good results were obtained with the manufacture of snacks based on raw soya, deoiled with

hexane, on the one hand, and maize or rice on the other, the induction heating of the extruders of types BC 45 and BC 72 avoiding in particular the presence of steam in the manufacturing workshop.

The sources of starch consist of cereal semolina, degermed maize, rice, wheat, sorghum, oats, barley, tapioca. It is of course also possible to use the starch contained in dehydrated potato, banana, manioc, and generally speaking vegetable powder, such as dehydrated fruit and vegetables. It is of course also possible to make use of starch modified by chemical or physical means. The sources of starch that are preferred according to the process of the invention are degermed maize, semolina, raw rice and wheat.

Besides starch, the food mixture may contain other ingredients such as proteins (soya proteins, suitably defatted meat or fish proteins, and lactoproteins), amino acids, vitamins, salts (for instance NaCl, $CaCO_3$, $CaHSO_4$, mineral oligoelements and if necessary ingredients such as sugar, colouring matter and aromas.

Uncrushed snacks may be coated with fats, sugar, colouring matter and aromas; on the other hand crushed snacks with a view to use as instant flour for gruels and beverages, may not contain such ingredients.

According to the process of the invention, it is possible to prepare dietetic snacks containing up to 25% and more of proteins (without decrease in the dispersion of the product and its swelling in water), but as a rule the proteins will be contributed by the soya, milk proteins and fish or meat proteins. Preferred starch and protein snacks are those which contain on the one hand soya and on the other degermed maize and/or rice; it is thus possible to prepare balanced nutrient foods similar to those of the C.S.M. type (corn-soya-milk) and R.S.M. (rice-soya-milk), advocated by Unicef for underfed populations.

It is of course also possible to incorporate amino acids (methionin and lysin for instance), taking into account the diet being proposed as well as semolina of dehydrated fruit and vegetables.

The extruder may have draw-plates of diameter varying from 2 to 6 mm and of oval section for the preparation of the expanded extrudate which is intended to be crushed to instant flour and semolina. The amount of expansion is an inverse function of the protein content.

With a 4 mm draw-plate there will be obtained for instance, for a content of 14 to 16% by weight water of constitution before treatment, a sausage having a diameter of 14 to 16 mm and a density of 0.22. With the same draw-plate, if the protein content exceeds 20% by weight the expansion is less, but still acceptable and a sausage is obtained of 8 to 12 mm diameter and with fine honeycombing.

Moreover, with an extruder furnishing a delivery of 100—110 kg/h of expanded products from an initial mixture containing about 15% by weight of water of constitution, in particular with the Creusot-Loire extruder type BC 72, it is as well to moisten at the moment of starting the first five kilogrammes approximately of initial mixture with 500 g water, after which the first 4 to 5 kilogrammes of expanded products are discarded, extrusion, cooking and expansion then taking place without any continuous contribution of water for 24 hours out of 24 until the machine is stopped.

This contribution of water in starting is designed to lubricate the first 2 co-penetrating screws or worms as well as all the other parts of the machine. This contribution of water takes place only when the initial mixture only contains 14 to 16% residual humidity. If the residual humidity of the initial mixture is less, since water is added to top up to 14—16% the content of drinking water, it is no longer necessary to add water in the starting phase.

In practice, with the extruder BC 72, a little water will therefore have to be added on starting each time an initial mixture is treated with 14 to 16% residual humidity, comprising (a) raw maize or wheat starch, and (b) deoiled raw soya, or milk lactoproteins, the protein content being between 15 and 30% by weight in relation to the weight of the initial mixture.

Besides purely dietetic applications, the process according to the invention also makes it possible to prepare dietetico-therapeutic products, in particular anti-diarrhoea products based an carob pulp, dehydrated carrot, or soya associated with tannin. Further advantages and characteristics of the invention will be better understood by reference to the following examples of preparation which are given by way of illustration only.

## Example 1
### Hyposoda protein food

With a Creusot-Loire extruder of type BC 45 with three heating rings (temperature and length of passage of the treated mass for each of the rings respectively; 40°C, 40 seconds; 120°C, 40 seconds; then 160°C, 40 seconds), a cooked, extruded and expanded product was prepared containing 7.27% by weight of humidity, 0.03% by weight of Na, 18.30% by weight of proteins, 1.70% by weight of lipids, 71.68% by weight of glycids and 0.84% of minerals from an initial food mixture comprising:

| | Parts by weight |
|---|---|
| fine decorticated raw rice or degermed raw maize semolina | 85 |
| milk powder proteins containing 75% by weight of lactoprotein | 15 |

Note: The milk protein is in the form of powder prepared by acid flocculation from lactoserum: the water content (water of constitution) of the initial mixture is 15%).

By crushing and cold dispersion in water (3 to 5 volumes of water), a gruel is obtained whose thickening persists for several hours.

Example 2

Composition of anti-diarrhoea foods

With a Creusot-Loire extruder, type BC 45 having three heating rings, temperature and passage time of the treated mix for each of the rings respectively: 40°C, 50 seconds; 70°C, 40 seconds; then 170°—180°C, 30 seconds), an anti-diarrhoea food composition was prepared from the following ingredients:

| | Parts by weight |
|---|---|
| dehydrated carrot (6% residual humidity | 6 |
| deoiled raw soya flour (containing 50% protein and 8% residual humidity) | 2.40 |
| pure oak bark tannin | 0.60 |
| NaCl | 1.00 |
| $CaCO_3$ | 0.8 |
| seeded and powdered carob pulp (6% humidity) | 10.00 |
| fine raw rice semolina (12% humidity) | 79.20 |
| vanillin | 0.02 |

The residual humidity of the initial mixture being about 10%, 5% water is added so as to be able to extrude a mix which only contains 60% of true starch. The total water content is about 15%. The final snack has a residual humidity of 7% by weight. By crushing and drying in a stream of air, a powder is obtained which has a residual humidity of 4.5% by weight.

Example 3

Anti-diarrhoea food composition

This example is concerned with a preparation based on carob, which is similar to the speciality termed "Caruba", containing to start with:

| | Parts by weight |
|---|---|
| seeded carob pulp, dried and powdered (6% residual humidity) | 50 |
| deoiled sunflower aleurone containing 50% by weight proteins (residual humidity 8%) | 15 |
| fine crude rice semolina (12% residual humidity) | 33.2 |
| NaCl | 1.00 |
| $CaCO_3$ | 0.80 |
| vanillin | 0.02 |

As the content of water of constitution is about 8%, humidification with 7% water is needed to arrive at 15% humidity as in the case of a cereal semolina without the addition of protein.

A Creusot-Loire extruder type BC 72 is used having four heating rings (temperature and passage time for each of the rings respectively: 40°C, 10 seconds; 120°C, 10 seconds; 160°C, 7 seconds; then 180°C, 3 seconds). A snack is obtained having a residual humidity of about 6% by weight. By crushing and drying in a stream of air, a powder is obtained having a residual humidity of 4% by weight. This final powder, which is very readily dispersible in water in the cold state (there is a continuous aqueous phase) can be used for preparing feeding bottles.

As regards the use of the snacks obtained according to the process of the invention, the following details are given:

1. Semolina and flour derived from the crushing of snacks can have a grain size of 400 to 600 microns. These products, diluted in 4 to 5 times their weight of water, furnish dispersions which thicken very quickly. The speed of hydration and the maintenance of a feeling of grains on tasting depending solely on the coarseness of the semolina, lumps are never formed during dilution, which is performed without precaution and in 30 seconds, for a dilution of 1/4 or 1/5, according to the type of starch, and the container may be inverted, the gel being rigid like a gelatinous product. For products of the compote type, sweet dishes, and above all gruels for feeding to children from the 5th to 6th month onwards, the preparation of formulae treated by this technique, or above all the addition of fine semolina, which may if necessary be coloured with edible red or chlorophyll green, or carrot red, will make it possible to impart body when used as additions to existing formulae, and in all cases it is likely that a mixture of amylon 7 (giving the appearance of pecten gel, fruit paste), together with a rice starch thus treated, will allow the instantaneous thickening of sweet courses containing milk in particular.

2. The products intended for feeding to children, such as stewed fruit dishes and gruels, can be made directly from starch and other ingredients or in two stages by cooking, extruding and expansion of the starch and then by the incorporation of the other ingredients. This latter solution has to be employed as soon as the fat content is higher than 2% by weight. Thus, whatever the solu-

tion adopted, it is possible to prepare food compositions coloured carrot red or chlorophyll green. As regards the sweet dishes, the association of a rice starch treated according to the invention, with a pectin, ensures instant thickening, especially for milk sweets and puddings.

3. In general, the thickening mentioned above is durable for more than 10 hours from the minute following dilution.

WHAT WE CLAIM IS:—

1. A process for cooking, extruding and expanding a food mixture containing starch, possibly associated with vitamins and protein materials by means of an extrusion press, wherein the food mixture which contains raw starch, a quantity of fats from 0 to 2% by weight in relation to the weight of the said food mixture and a total amount of water of 14 to 16% by weight in relation to the weight of the said food mixture, is cooked, extruded and expanded by means of an extrusion press having (a) two co-penetrating worms and a draw plate avoiding the stagnation of material and (b) at least one heating device.

2. A process according to Claim 1, characterised in that the food mixture is subjected to heat treatment at a pressure greater than or equal to 200 kg/cm$^2$ for 20 to 150 seconds.

3. A process according to Claim 2, wherein the heat treatment comprises at least two stages, one consisting of preheating to 40°C and the other of heating to a temperature between 120° and 180°C.

4. A process according to Claim 3, wherein the heat treatment comprises preheating at 40°C for 40 seconds, heating at 120°C for 40 seconds and then heating at 160°C for 40 seconds.

5. A process according to Claim 3, wherein the heat treatment comprises preheating to 40°C for 50 seconds, heating to 70°C for 40 seconds and then heating at 170°C to 180°C for 30 seconds.

6. A process according to Claim 3, wherein th heat treatment comprises preheating at 40°C for 10 seconds, heating to 120°C for 10 seconds, heating to 160°C for 7 seconds then heating to 180°C for 3 seconds.

7. A process according to any of Claims 1 to 6, wherein the starch is selected from maize, rice and wheat starch, and in that the protein substances are selected from soya, milk, deoiled sunflower aleurone, meat and fish proteins.

8. A process according to any of Claims 1 to 7, wherein the food mixture comprises 15 parts by weight of a dry extract of lactoserum containing 75% by weight lactoproteins and 85 parts by weight of semolina from cereals selected from raw rice or degermed raw maize.

9. A process according to any of Claims 1 to 7 wherein the food mixture contains 50 parts by weight of seeded and dried carob pulp, 15 parts by weight of deoiled sunflower aleurone and containing 50% by weight of protein in relation to the weight of sunflower aleurone, 33.2 parts by weight of rice semolina, 1 part by weight of NaCl, 0.80 part of $CaCO_3$ and 0.02 part by weight vanillin.

10. A process according to any of Claims 1 to 7, wherein the food mixture contains 6 parts by weight of dehydrated carrots containing 6% by weight residual humidity, 2.40 parts by weight of deoiled raw soya and having a protein content of 50% by weight, 0.6 parts by weight of oak bark tannin, 1 part by weight NaCl, 0.80 part by weight $CaCO_3$, 10 parts by weight dehydrated seeded carob pulp containing 6% by weight residual humidity, 79.20 parts by weight raw rice containing 12% by weight residual humidity and 0.02 part by weight vanillin.

11. A process according to any of Claims 1 to 10 wherein the initial extruded portion of mixture has water added thereto to aid in moistening the extrusion press.

12. A process as claimed in Claim 1 and substantially as herein described.

13. A process substantially as herein described in any one of the accompanying examples.

14. Dietetic and dietetico-therapeutic products obtained according to the process of any of the Claims 1 to 13.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.